

NRC Fire Risk Research Triangle



U.S. Nuclear Regulatory Commission



NRC FIRE RISK RESEARCH TRIANGLE

The NRC Office of Nuclear Regulatory Research (RES) is actively pursuing a number of research activities in the area of fire risk/fire safety. RES has created a Fire Research Team within the Division of Risk Analysis and Applications to focus on improving the agency's knowledge where uncertainty exists, and where safety margins are not well characterized, in support of regulatory decisions for existing or new designs and technologies with respect to fire safety. This poster session illustrates how three major programs within the Fire Research Team interact and support the agency's goals. The poster also illustrates some of the professional partnerships developed with other agencies and stakeholders in pursuing this safety mission.

FIRE MODELING V&V [Joint NRC/RES, NIST, and EPRI Project]

The fire model verification and validation (V&V) will verify and validate 5 different fire models using guidance from ASTM E 1355, Standard Guide for Evaluating the Predictive Capability of Deterministic Fire Models, using data from 26 different fire experiments. Over the past decade, there has been a considerable movement in the nuclear industry to transition from prescriptive rules and practices towards the use of risk information to supplement decision-making. The NRC now permits licensees to voluntarily adopt risk-informed, performance-based (RI/PB) fire protection requirements as an alternative to the existing deterministic fire protection requirements. RI/PB fire protection relies on fire modeling for determining the consequence of fires. The fire model V&V will provide guidance for using fire models.

What the Picture Shows:

The photo shows an image from a computer simulation using the Fire Dynamics Simulator (FDS), available from the National Institute of Standards and Technology (NIST).

Why Fire Model V&V is Important:

Fire Model V&V is Important because it supports RI/PB fire protection by verifying and validating key tools used for analyses in nuclear power plants, including comparisons of fire models' predictions with experimental data.

Uses for Current Regulatory Issues:

1) The RI/PB fire protection requirements contained in 10 CFR 50.48 (c) and NFPA 805, Performance-Based Standard for Fire Protection for Light Water Reactor Electric Generating Plants, require that "fire models shall be verified and validated," and "only fire models that are acceptable to the Authority Having Jurisdiction (AHJ) shall be used in fire modeling calculations."

2) Fire modeling tools are used in the significance determination process (SDP) of the reactor oversight process to disposition inspection findings.

3) Fire modeling tools are used in licensing requests.

Uses for Fire Risk Analysis of Operating Plants:

Fire models are used in Fire PRAs to determine what equipment may be available in case of a fire. A better understanding of the capabilities of the modeling tools will allow fire PRAs to more accurately identify areas where additional fire prevention or mitigation efforts would be most effective in reducing plant risk.

Uses for Next Generation Nuclear Power Plants:

Licensees who choose to adhere to the RI/PB fire protections requirements can use the information and guidance in the Fire Model V&V NUREG 1824 for fire model applications.

Planning, Status, Publication of Reports:

Planning for the fire model V&V started in 2003. The analysis was performed in 2004 and 2005. Draft NUREG 1824 Volumes 1-7 was issued for public comment in January 2006. The final report is expected to be published in August 2006. The final report will include copies of the models, supporting documentation, and input files.

FIRE PRA [Joint NRC/RES and EPRI Project]

The improved fire PRA methodology project will make significant improvements in existing fire PRA methods, tools, and data, including addressing gaps in previous approaches. The jointly produced document, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," will provide a comprehensive approach for evaluating those fire PRA elements primarily characterized by detailed event trees/fault trees. Since this consensus approach was developed through a broad set of experiences from RES/EPRI collaboration, it is expected that it will assist the technical community in reaching greater stability and convergence in applying Fire PRA.

What the Picture Shows:

The photo shows an illustrative, simplified fire PRA event tree for a fire initiating from a cabinet in a cable spreading room containing redundant trains. Fire development and spread, including the impact of fire brigade suppression activities, are incorporated. Plant response after fire damage is represented by the conditional core damage probability (CCDP).

Why An Improved Fire

PRA Methodology Is Important:

Improvements in fire PRA methods were needed to provide increased realism in fire PRA estimates for risk-informed, performance-based fire protection, and to address known shortcomings and weakness in existing methods. Examples of notable improvements include the identification of challenging fires for purposes of frequency and suppressing quantification, improved treatment of circuit analysis issues including multiple spurious actuations, development of an approach for assessing high energy arcing faults, and better alignment of the analysis with post-fire safe shutdown considerations.

Uses for Current Regulatory Issues:

1) Support implementation of the new fire protection rule 10CFR50.48(c) [the risk-informed, performance-based rule endorsing NFPA Standard 805 for permanent changes to the fire protection licensing basis]

2) Provide a basis for developing the ANS Fire Risk Standard which will support 10CFR50.48(c) analyses [Note: This ANS Standard is under development]

3) Provide a basis for developing the existing Fire Protection Significance Determination Process (SDP) for evaluating inspection findings

4) Support evaluation of risk-informed fire protection exemption/ deviation requests

5) Support evaluation of risk-informed fire-related (as opposed to fire protection related) technical specification changes

Uses for Improved Fire PRA Methodology in Operating Plants:

This new methodology will be used in risk-informed decision-making with regard to permanent changes to the licensing basis of existing plants through the new rule, 10CFR50.48(c), and its supporting technical documents, e.g., the ANS Fire Risk Standard. Also, this methodology will support decision-making for evaluating temporary conditions at nuclear power plants through its influence on fire protection SDP and more refined analyses of inspection findings.

Uses for Next Generation Nuclear Power Plants: This improved fire PRA methodology will enable better incorporation of risk considerations in the planning of fire protection defense-in-depth features. For example, cable routing paths can be selected to avoid high risk plant configurations resulting from fire damage to cables.

Planning, Status, Publication of Reports:

The joint NRC/EPRI document, "EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities," was published in September 2005. Addenda to this document may be developed from feedback from continuing plant applications.

A workshop on this program was held at the EPRI facility in Charlotte, NC, in June 2005. A second workshop at NRC headquarters in Rockville in May 2006 is being planned.

CAROLFIRE (CAble Response to Live Fire) [Joint NRC/RES, SNL, NIST, & UMD Project]

CAROLFIRE will perform multiple tests (~114) of electric instrumentation and control cables with various types of insulation, in different configurations and combinations, exposed to radiant heat from an electric heater and to heat from actual flames, in test facilities at the Sandia National Laboratories.

What the Picture Shows:

The photo shows a cross section of fire damage to two nine-conductor and six single-conductor electric cables (Note that certain conductors are close to shorting, both inter- and intra-cable).

Why Electric Cable Fire Testing Is Important:

1) To determine the conditional probability of hot shorts between cable conductors given cable damage from a thermal insult, and the conditional probability of circuit malfunctions given those hot shorts; and

2) To support the development of improved fire modeling tools, specifically exploring when cable damage results from the thermal insult, and how this can be represented in fire models

Determination of the risk due to fire damage to nuclear power plants' electrical cables has been an issue for many years. Some licensees assumed unavailability of the safety function of any system whose electric cables pass through a fire-damaged compartment.

While this is one possible failure mechanism, recent testing and greater use of risk-informed methods show hot shorts can contribute greater risk than previously postulated. This risk needs to be accounted for in plant risk analyses, and therefore realistic, experimentally measured hot-short and circuit malfunction conditional probabilities need to be developed. In addition, fire modeling tools need to be improved to calculate probabilities for applications not specifically tested.

Uses for Current Regulatory Issues:

1) NRC Regulatory Issue Summary (RIS) 2004-03, Rev. 1, "Risk-Informed Approach for Post-Fire Safe Shutdown Circuit Inspections," identifies several "Items to Be Deferred at This Time, Pending Additional Research." CAROLFIRE will provide the additional research to determine if the frequency of those items is low enough to justify their preclusion from future inspections, or high enough that they should be inspected.

2) The time-to-failure of electric cables under thermal insult is subject to large uncertainties. Time-to-failure is an important parameter used in the Significance Determination Process (SDP). CAROLFIRE data will aid development of better fire modeling tools that will reduce the uncertainties in SDP applications.

Uses for Fire Risk Analysis of Operating Plants:

The conditional probabilities will be used in the associated FIRE PRA effort as input information, and the heat flux and temperature data will be used in the associated FIRE MODELING V&V effort to develop more realistic fire modeling tools. The better conditional probabilities and modeling tools will allow fire PRAs to more accurately identify areas where additional fire prevention or mitigation efforts would be most effective in reducing plant risk.

Uses for Next Generation Nuclear Power Plants: CAROLFIRE data will enable new design plants to avoid the cable types, sizes, materials, and routing geometries that are most likely to result in circuit malfunctions caused by hot shorts between cable conductors.

Planning, Status, Publication of Reports:

The planning for this project was performed in 2005. Fire testing began during the first quarter of CY 2006, with the analysis to be performed in the summer and fall of 2006.

Two final reports are expected to be published in December 2006, the first providing cable and circuit data, and the second providing data to support development of improved fire modeling tools.

